

CANARY ROCKFISH
STAR Panel Meeting Report

Northwest Fisheries Science Center
Seattle, Washington
April 15-19, 2002

STAR Panel Members:

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Stephen Ralston, SSC Representative and second rapporteur, NMFS SWFSC, Santa Cruz, CA
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STAT Team Members Present:

Richard Methot, NMFS, NWFSC, Seattle, WA
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FINAL STAR Report, May 7, 2002

Canary Rockfish STAR Panel Report

Overview

The STAR Panel reviewed the draft assessment report by the STAT Team for the canary rockfish resource. The review took place during the week of April 15-19, 2002 at the Montlake Laboratory of NMFS Northwest Fisheries Science Center in Seattle, Washington. The STAT Team provided the STAR Panel members with a draft report in advance of the STAR workshop documenting the analyses completed prior to the meeting. The STAT team of Rick Methot and Kevin Piner was present during the week. On the first day Methot and Piner summarized their draft document including descriptions of the fishery, the biology of canary rockfish, available data, relevant features of their stock synthesis model and assumptions, and initial results of alternative modeling scenarios. Considerable discussion followed over the week concerning the quality of the data, appropriateness of model assumptions, base model configurations, potential alternative configurations, and interpretation of results. The Panel requested additional alternative model analyses to examine sensitivity of assessment results focusing on areas of data uncertainties and configuration assumptions. The STAR panel and STAT team discussions resulted in developing a new baseline model that treated the canary resource off California, Oregon, and Washington as one stock, assumed catches for pre-1941 period to 500 mt per year, modeled female mortality as an increasing function of maturity (age), allowed female dome-shaped selectivity at older ages, used of B-H spawner-recruit relationship to estimate current recruitments, use of a parametric bootstrap of residuals and fitted stock recruitment curve for forecasting future recruitments and projecting rebuilding rates. There was agreement that future assessment efforts should include Canadian data because the west coast stock of canary rockfish most likely extends into British Columbia. Agreement was reached on how best to provide model results that capture the range of uncertainty in the assessment and how to best depict the uncertainty in a figure that would assist the Council decision process. The team developed a figure that shows the probability of stock recovery to B40 over time for three assumed levels of asymptotic female natural mortality for alternative values of F or annual catch. The week following the STAR meeting the Team revised the draft canary report incorporating the work conducted during the STAR meeting and, specifically, analyses for the uncertainty/decision figures. They provided the simulation results to project stock rebuilding forecasts given current status of the resource using the new baseline model assuming 3 levels of asymptotic female natural mortality ($M = 0.10, 0.12, \text{ and } 0.14$) and for as many as 5 levels of fishing, i.e. 50 mt, 93 mt, $F = 0$, $F = 0.005$, $F_{90\%}$. In addition the STAT team also re-evaluated the steepness estimate for the spawner-recruit relationship from the baseline model. This estimate was 0.289 for $M = 0.12$, yet the best fit of steepness estimated from direct fit of the estimates of recruits and spawning biomass from model output is 0.330. Because this range in steepness parameter has a major impact on the rebuilding forecasts, the Team included the range of steepness in their rebuilding forecast. Although the STAR Panel has had only limited opportunity to review these latter results, we conclude that their approach to addressing range of uncertainty is appropriate, is presented in a format that should be helpful to the Council decision process, and captures the range of uncertainty. The consensus of the STAR Panel is that the canary assessment model is sufficient for assessing the current status of the resource and provides the basis for re-analysis of the rebuilding the canary rockfish stock.

I. Minutes of the STAR Panel Meeting

The STAR Panel commends the canary rockfish STAT team for their work on the canary rockfish stock assessment. Relatively complete and clear documents were distributed early. All additional analyses were carried out quickly and with considerable technological innovation. The analysis, even before alterations suggested by the STAR panel, involved substantial improvements to the understanding of canary rockfish.

Analyses Requested by the STAR Panel

Monday, 15 April

- 1) Determine the sensitivity of virgin biomass and depletion estimates to assumptions about catch prior to 1941. In particular, determine if estimates are sensitive to the assumption that the stock was unfished in 1940.
- 2) Determine the sensitivity of virgin biomass, depletion ratio, and recent biomass trends to treatment of triennial survey data for 1977 and 1980. Model runs already discussed used the survey biomass (trend) estimate for 1980 but not the length composition data for 1980 and neither the survey biomass nor length composition data for 1977. In the first sensitivity analysis, incorporate the length composition data for 1980. In the second run, incorporate the survey biomass and length composition for 1977 as well.
- 3) Plot preliminary recruitment estimates from the stock synthesis model against the Tiburon pelagic juvenile trawl data to see if the latter might be useful as a recruitment index for canary rockfish.
- 4) As a sensitivity analysis, add survey and catch data from Canadian waters to the model. This suggestion is technically sensible because canary rockfish on both sides of the US/Canadian border are believed to belong to the same biological stock. Consequently, inclusion of all pertinent Canadian information should be pursued in future assessments. However, the preliminary nature of the Canadian data precluded their use in this assessment. For this reason the STAR panel recommends that sensitivity analysis runs with Canadian data not be used for management purposes.
- 5) Make certain that any assumptions (or estimates) about catch during 2000 and 2001 are the same as used by the GMT.
- 6) Selectivity curves for California non-trawl, California recreational and Oregon recreational fisheries were implausibly peaked in preliminary runs. As explained by the STAT Team, this tendency was probably exacerbated by relatively sharp modes in length composition data and relatively large assumed variances in length at age. Basically, a single age group is assumed associated with a range of lengths that is wide enough to explain the range of lengths in the modes of length composition data. As a sensitivity analysis, reduce the assumed variance in size at age and re-run the model to see if selectivity curves are less peaked and are more credible.
- 7) Preliminary projections and reference point calculations used averaged relative F 's and average selectivities for commercial and recreational fishery sectors during 1997-2001. However, the relative importance of commercial and recreational fisheries changed

substantially in 2000 due to restrictions on the commercial catch. Furthermore, changes in length composition data seem to suggest changes in selectivity for some sectors at about the same time. Use a shorter time period or different approach to estimating relative F 's by sector and overall fishery selectivity for use in projections and rebuilding plans.

- 8) Plot proposed natural mortality schedules as a function of length, as well as age, and indicate the lengths at first, median, and full maturity (i.e., length data may be easier to interpret than age data and are less subject to error).
- 9) Calculate a CV for current biomass based on the delta or other method.
- 10) Provide a straw man format for a decision table analysis.

Tuesday, April 16

- 11) In base model runs, assume catches pre-1941 were ~500 mt per year, rather than zero. This is discussed below.
- 12) Devise a model that blends the hypotheses that: i) natural mortality increases with age in females; and ii) fishery selectivity declines with age in females. This might be done by fixing an increasing trend and level of natural mortality while allowing the model to estimate declining selectivity with age.
- 13) As a sensitivity analysis, devise a model scenario that has high fishery selectivity on females throughout the historical and recent periods to see if such a pattern can explain the relative absence of large females from recent fishery data.
- 14) It was agreed that a parametric bootstrap for process errors in a spawner-recruit relationship would be a reasonable way to simulate rebuilding trajectories. However, it is necessary to examine the actual distribution of residuals (e.g. lognormal, gamma, etc.) and to determine if they are autocorrelated.
- 15) Organize software to construct likelihood-based confidence intervals (based on the chi-square distribution) for recent biomass/virgin biomass and other key parameters. This will involve profiling over a range of values for a suitable parameter (e.g. triennial trawl survey Q or natural mortality rate M) and taking the confidence interval for Q (or M) as a confidence interval for biomass ratios and other parameters.

II. Comments on the Technical Merits and/or Deficiencies in the Assessment and Recommendations for Remedies

Monday, 15 April

- 1) It was agreed that use of the annual catch data during 1941-1966 was better than using an average value calculated from the same data, if only to capture the apparent peak in catches during 1941-1946. However, there was considerable discussion about assuming that the stock was unfished in 1940 because this implies an abrupt increase in catch from zero to about 3,000 mt per year during 1940-1941. Sensitivity analyses were requested to determine effects of assumptions on estimates of virgin biomass (see above).
- 2) It is sensible to start the model in 1941, rather than 1967, so that the time series of historical catches can be used to full advantage.
- 3) There is no evidence that canary rockfish in the northern and southern stock assessment areas are different biological stocks. It is sensible to model canary rockfish as a single coast-wide stock.
- 4) It is not clear if length composition data computed as weighted averages are better estimates of catch length composition than a simply combining samples. The STAR Panel saw no reason to recommend one or the other.
- 5) Treatment of triennial trawl survey data for 1977 and 1980 were discussed at length. Lack of complete coverage in shallow water in 1977, sensitivity of mean catch rates for 1977 to exclusion of 'water hauls', and lack of length measurements from tows with small catches during 1977 and 1980 are key issues. However, relatively few canary rockfish are present in the strata skipped during 1977, water-haul tows are now excluded routinely, and length composition data may have been little affected by lack of measurements from small catches. Sensitivity analyses were requested to determine if estimates of virgin biomass and trend were sensitive to assumptions about the 1977 and 1980 survey data.
- 6) Preliminary Canadian catch data should be verified; it is possible that estimates prior to 1983 are too low due to a correctable error.
- 7) It was agreed that modeling of CPUE data with an exponent to account for nonlinearity was a reasonable approach for the canary rockfish assessment.
- 8) The STAR Panel agreed with the STAT team's conclusion that some lack of fit in residual plots from the age-based synthesis model were unavoidable because it is not possible, in the age-based synthesis model, to change growth patterns sufficiently to fit age and length composition data from the same survey perfectly. Despite some residual patterns, it was agreed that goodness of fit to age and length composition data was good overall and was generally acceptable.
- 9) It was agreed that extremely peaked selectivity patterns for non-trawl and recreational fishery segments were implausible. A different parameterization might be helpful. In addition, sensitivity analyses were requested to determine if an overestimate of the variance in size at age might be contributing to the problem.

- 10) It was agreed that base model runs should assume or accommodate the notion that the natural mortality rate (M) increases in larger/older females, based on extensive analysis in the draft stock assessment. The alternate hypothesis that selectivity decreases may hold as well, but increased natural mortality in large/old females seems quite probable.
- 11) In the next assessment all party boat logbook data sources should be investigated and updated where possible.
- 12) Decisions about time periods for selectivity parameters seemed reasonable given recent changes in management of the fishery. However, estimating new parameters starting in 2000 (when regulations changed) means that recent age and size composition data provide little information for parameter estimation.
- 13) Use of the stock recruitment curve as an estimate of recent recruitments seems reasonable but we have to acknowledge almost complete lack of information concerning the strength of recent recruitments.
- 14) The STAR panel agreed with the STAT Teams decision to base projections on a parametric bootstrap of residuals and an underlying stock recruitment curve.
- 15) At the end of the first day of discussion, there were major technical uncertainties related to how to measure and express uncertainty in estimates of virgin biomass and current stock size. Typical variance estimates are not available in the age structure stock synthesis model.
- 16) It was agreed that the assessment reviewed by the STAR panel should provide the building blocks for rebuilding time analyses but that it may be impossible to carry the analyses out in the assessment itself.

Tuesday, 16 April

- 17) The STAR panel agreed with the STAT team's decision to use an emphasis of 0.1 for all length composition data sets and a value of 0.9 for age composition data when both length and age composition data were available. This approach uses all available information, emphasizes use of the age data (which are more informative), and avoids "double counting".
- 18) There was considerable rockfish catch in California, Oregon and Washington prior to 1941 and the best available information (from limited sampling after 1941 in central California) suggest that roughly 18% was canary. Thus, the assumption that the canary fishery was unexploited in 1940 seems untenable. A quick calculation (to be elaborated upon in the assessment document) suggests that canary catches prior to 1940 was about 500 mt per year. The base model run should assume that the stock was in equilibrium with a catch of 500 mt per year in 1940.
- 19) Two explanations regarding the relative scarcity of old and large female canary rockfish in age and length composition data was discussed. One hypothesis asserts that the scarcity is

due to reduced selectivity for large females. The other hypothesis asserts that the scarcity is due to higher natural mortality in large females, presumably due to stress from reproduction. The draft assessment presented information and arguments suggesting that natural mortality increases. The selectivity hypothesis is supported by certain life history considerations, which suggest that some species of rockfish move to deeper and rockier habitats as they age. Previous assessments portrayed these hypotheses as competing and presented ‘extreme’ alternate model scenarios assuming one hypothesis or the other.

- 20) The STAR panel pointed out that the two hypotheses were independent, rather than competing because an increase in natural mortality might occur with or without reduced selectivity for older females. In fact, based on available age composition data, maximum age information, and general biological considerations, the majority of the STAR panel felt that both hypotheses were likely valid to some extent. That is, it seems plausible that older females have elevated natural mortality and potentially reduced fishery selectivity.
- 21) An approach to building a blended model starts with the relatively certain conclusion that natural mortality increases with age and the hypothesis that increased natural mortality is linked to maturity and stress due to spawning. In particular, it seems reasonable that the increase in natural mortality should be linked to the increase in proportion mature with size and age.
- 22) Starting with the assumed natural mortality rate for young females (M_{base}), the model should be able to estimate a parameter m that increments natural mortality as (for example) $M(a) = M_{base} + p(a) * m$ where $p(a)$ is maturity at age (or some function of maturity at age). It may be possible to simultaneously estimate both the mortality increment parameter and domed shape selectivity for females. This approach embraces both hypotheses while using the data to estimate parameters for both.

Wednesday, April 17

- 23) After some exploration, the STAT team proposed to use a relationship between natural mortality and age of the form $M(a) = M_{base} + p(a)^3 * m$ because the cubic exponent delays the onset of increased mortality somewhat. The STAR panel agreed with this proposal.
- 24) Estimated declines in selectivity and increases in maturity for females occur at ages near the accumulator age (23 years) used in the current assessment. Canary are a relatively long-lived fish and, in future assessments, it might be advisable to use an older age as (e.g. 30-35 years) as a plus group.
- 25) The STAR panel agrees that the 1982 logbook catch rate for canary is an outlier that should be omitted from the analysis.
- 26) The STAR and STAT panel agreed that a reasonable approximation to confidence interval on current biomass, current biomass/virgin biomass and other parameters could be formed by considering a likelihood profile on the female natural mortality rate parameter (m , see above). One end of the interval is defined at $m=0$ (no increment to natural mortality for females) because the probability that $m=0$ is likely near zero. Under the circumstances, it seems reasonable to interpret the likelihood profile as a probability distribution in associating probabilities with each value of the female increment mortality parameter m .

- 27) Variability in recruitment appears to be autocorrelated in canary with periods of higher and lower recruitment than expected based on the estimated spawner-recruit curve. Autocorrelation may have important ramifications in rebuilding time calculations when starting at low stock biomass levels. In particular, autocorrelation may increase rebuilding time. If possible, sensitivity of rebuilding time calculations to assumptions about autocorrelations in recruitment should be evaluated.
- 28) There is uncertainty in the distribution of residuals around the stock-recruitment curve. The lognormal distribution is assumed traditionally but it may not mimic the true distribution of very large and very small residuals. Assumptions about lognormal distributions have attracted considerable criticism in the literature. If possible, sensitivity of rebuilding time calculations to assumptions about the distribution of recruitment variability should be evaluated.
- 29) Rebuilding time calculations may be sensitive to errors in biomass estimates, particularly if the rebuilding plan uses harvest rates. Errors in biomass estimates and implementation errors (e.g. overages in catch due to unaccounted bycatch) should be included in rebuilding time calculations.

Thursday, April 18

- 30) Addition of the Canadian data and the triennial shelf survey catch rates from the Canadian Vancouver area results in a better fit to the overall survey trend (root mean squared error = 0.39 vs. 0.57). The terminal biomass is almost identical to the model with the Canadian information excluded, but the initial biomass is slightly larger. For that reason the depletion level is slightly lowered. Recruitments variability is unaffected, because no age or length composition information is available, but the time series is marginally shifted up. In the sensitivity analysis, the survey catchability (Q) went from 0.4 to 0.6 with the Canadian information included, ostensibly because the survey trend showed a greater decline.
- 31) Preliminary rebuilding trajectories were calculated using the Stock Synthesis projection module. Graphs were presented showing preliminary results from 1,000 realizations with a terminal female mortality rate equal to 0.10 for old large individuals (in the base model it is 0.12). If rebuilding is projected using the same approach as previously employed (R/S and no catch) the minimum time to rebuild is 10 years greater than before. The STAT team also used the spawner-recruit curve to project with no fishing, which shifted the cumulative probability distribution slightly to the right (i.e., longer times to rebuild).
- 32) If one uses trawl selectivity to project with 93 mt fixed catch, then 50% of the preliminary simulations rebuilt 3 years after the maximum time allowable (T_{max}); if recreational selectivity is used to project the population, then the stock will reach the rebuilding target with 50% probability 14 years after T_{max} . With a blended selectivity curve (trawl and recreational) and a constant harvest rate equal to $F=0.005$ the stock could rebuild within the current T_{max} . However, initial catches under that preliminary scenario are quite low (~20 mt)

- 33) Due to the importance of the fishery selectivity curve used in projections, the STAR panel recommended that projections should include a variety of assumptions about selectivity, ranging from full trawl to full recreational selectivity curves.
- 34) The STAR selected a base model that had the female natural mortality rate linked to the maturity curve, increasing to a maximum value of 0.12.
- 35) The STAT team indicated that they would include an evaluation of the Canadian data in the assessment document as a sensitivity analysis only.

III. Explanation of Areas of Disagreement Regarding STAR Panel Recommendations

There were no areas of disagreement, either among STAR panel members or between the STAR panel and the STAT team. It is the consensus conclusion of the review panel that the assessment represents the best available scientific information regarding the status of the canary rockfish stock and that its conclusions will be useful in providing guidance on management and the likelihood of stock rebuilding.

IV. Unresolved Problems and Major Uncertainties

The STAR panel and STAT team agreed that a uncertainty/decision graph would be constructed that represented three states of nature, i.e., terminal female natural mortality rate equal to 0.10, 0.12, and 0.14 yr⁻¹. Results presented by the STAT team showed that range covered the likely extent of plausible values in the base model. Moreover, over that range of terminal M values the stock is estimated to be 7-11% of the unexploited biomass, which is consistent with the previous stock assessment and rebuilding analysis. Over that range spawning biomass in 2002 is estimated to be approximately 2,000-4,000 mt. To capture the range of uncertainty for the Council decision process, the Team provided the simulation results to project stock rebuilding forecasts given current status of the resource using the new baseline model assuming the 3 levels of asymptotic female natural mortality ($M = 0.10, 0.12, \text{ and } 0.14$) and for as many as 5 levels of fishing, i.e. 50 mt, 93 mt, $F = 0, F = 0.005, F_{90\%}$. In addition the STAT team also re-evaluated the steepness estimate for the spawner-recruit relationship from the baseline model. This estimate was 0.289 for $M = 0.12$, yet the best fit of steepness estimated from direct fit of the estimates of recruits and spawning biomass from model output is 0.330. This approach external to the model is reasonable because, unlike the spawner-recruit models fit within stock synthesis, external estimates are less affected by data for years outside the range of spawner-recruit estimates used to fit the curves. These analyses suggest that the spawner-recruit steepness parameter (which measures average spawner-recruit productivity at low spawning biomass levels) for canary rockfish is low relative to other groundfish species. Thus, surplus production of canary rockfish at low biomass levels is expected to be relatively low and rebuilding times are expected to be relatively long, even at zero or low levels of fishing. Although this general pattern appears certain, uncertainty in estimates of the spawner-recruit steepness is a key uncertainty in rebuilding time calculations. Sensitivity and rebuilding analyses carried out after the STAR Panel meeting show that minor changes in estimation procedures give rise to relative small changes in steepness estimates that have substantial changes to estimated distributions for rebuilding times. Although it does not appear possible to resolve the uncertainty in steepness, the Team will prepare a likelihood profile for steepness using the new baseline model for $M = 0.12$. Because this range in steepness parameter has a

major impact on the rebuilding forecasts, the STAR panel encourages the Team to include the range of steepness in their rebuilding forecast scenarios.

V. Recommendations for Future Research and Data Collection

- 1) In the future it would be desirable to incorporate all Canadian data sources (i.e., catches, survey abundance statistics, and age/length compositions) into the modeling framework because a significant portion of the canary rockfish stock resides to the north of the assessment area. This will require close cooperation with Canadian scientists.
- 2) There is inadequate information to identify the benthic habitats to which very young fish recruit. If such habitats were known, it would be desirable to sample them to develop a pre-recruitment survey.
- 3) There is a large quantity of trawl logbook data from all three States that dates back to the 1950's and has not been computerized. Those data should be identified, keypunched and combined in an analytical framework that utilizes port-specific species composition information to try and extend the trawl logbook time series of canary rockfish CPUE.
- 4) A re-examination of canary rockfish otoliths from ODF&W collections may reveal whether there has been a systematic change in age determinations over the last 20 years. This is especially important for the 25+ accumulator age group.
- 5) Due to the increased significance of non-trawl fisheries, particularly in the northern area, it is important that adequate resources be devoted to acquisition of information from the fixed gear fisheries, including the recreational sector.
- 6) Some uncertainty remains about whether the scarcity of old female canary rockfish is due to an accelerated natural mortality schedule, to decreased availability to sampling devices, or to a combination of factors. Hook-and-line and ROV/submersible surveys could prove useful in determining if older females are located in areas that are inaccessible to surveys and commercial fisheries. Although it is impossible to determine fish ages using visual sampling methods, if specific locations are identified that contain very large canary rockfish, these could then be targeted with hook-and-line gear (perhaps vertical longlines).
- 7) Monitoring of canary rockfish rebuilding will depend critically on the continuation of existing fishery-independent surveys (e.g., the shelf trawl survey). New and innovative survey methodologies (e.g., ichthyoplankton surveys to estimate female spawning biomass) should also be considered.
- 8) Party boat logbook data should be updated for the next assessment.
- 9) Variance estimates by some standard means (e.g., bootstrapping, MCMC, etc.) should be produced for the next assessment. There are no technical obstacles to generating these

useful and standard estimates of uncertainty.

- 10) Selectivity functions used for canary rockfish in the stock synthesis model tend to be implausibly peaked, with first and second derivatives that change abruptly with age and size. Smoother distributions, with continuous derivatives should be investigated in future assessments.